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TRANSPORT OF TRACE CONTAMINANTS THROUGH POROUS MEDIA

SEMI-ANNUAL STATUS REPORT NO. 3

for the period from

16 March 1975 to 15 September 1975

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Principal Investigator: Richard Mader

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Kent State University

Kent, Ohio 44242

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# TRANSPORT OF TRACE CONTAMINANTS THROUGH POROUS MEDIA

## SEMI-ANNUAL STATUS REPORT NO. 3

for the period from

16 March 1975 to 15 September 1975

### Summary

Research accomplishments during the report period include (1) the calibration of the gas chromatograph for acetaldehyde and ethanol; (2) the development of data reduction and analysis methods; (3) the generation and analysis of experimental data for the transport of 100 ppm acetaldehyde through a cylindrical bed packed with activated carbon granules; (4) the generation and analysis of experimental data for the transport of 100 ppm ethanol through a cylindrical bed packed with activated carbon granules; and (5) a comparison of the volume adsorption capacity of activated carbon for 100 ppm concentrations of acetaldehyde, ethanol, and acetone.

Activities in progress include (1) the generation and analysis of experimental data on the transport of freon 113 ( $C_2Cl_3F_3$ ) through activated carbon; (2) the generation and analysis of additional experimental data on the transport of ethanol through activated carbon; and (3) the interpretation of dispersion as a function of superficial

flow velocity for acetaldehyde and ethanol.

Planned activities include (1) the preparation of papers for publication; (2) the generation of experimental data on the adsorption isotherms of acetaldehyde, ethanol, and freon-113 on activated carbon at 25°C; and (3) the generation of experimental data on the transport of methane through activated carbon.

## RESEARCH ACCOMPLISHMENTS DURING THE REPORT PERIOD

### 1. Calibration of the Gas Chromatograph for Acetaldehyde and Ethanol.

Calibration data were generated to determine the response of the gas chromatograph (G.C.) system to concentrations of acetaldehyde and ethanol in the range from 10 ppm to 100 ppm. We start with a tank of 100 ppm of contaminant (e.g., either acetaldehyde or ethanol) in helium. We dilute this concentration with additional helium in order to obtain desired contaminant concentrations down to 10 ppm. The procedure for generating the calibration data consists of three parts: (1) Mix the contaminant mixture with pure helium and obtain a desired contaminant concentration. (2) Determine the G.C. system response for each concentration of contaminant. (3) Fit the response curve obtained in step (2) with an analytic function.

The flow system as given in Fig. 1 consists in part of two flow controllers at the inlet of the system and one valve at the outlet of the system. The two inlet flow controllers (FC1 and FC2) regulate the input of a maximum of two gas flows to the system. The outlet valve V7 divides the flow between the exhaust and the column sampling valve. The procedure for mixing two gases is as follows. The contaminant



gas, which consists of 100 ppm acetaldehyde (or ethanol) in helium, is input to flow controller one (FC1); and pure helium is input to flow controller two (FC2). A flow of 100 cc/min is used as the standard total flow consisting of the sum of the outputs from FC1 and FC2.

The contaminant flow (FC1) and the helium flow (FC2) are adjusted so that the ratio of contaminant flow to the total flow equals the desired concentration ratio.

$$\frac{FC1}{FC1 + FC2} = \frac{C}{C_0} \equiv T \quad (1)$$

The right-hand member follows from the definition of the transmission T, which is the ratio of outlet concentration from an adsorber bed to the inlet concentration.

The error associated with the flow mixture was determined by first measuring each flow separately and adding the two results together. This sum was then compared to the combined or total flow which was measured also. For each concentration of contaminant, the error is the deviation of the measured total flow from the sum of the individual flows. In the analysis, we used the maximum error obtained for all concentrations of contaminant.

The maximum error in the flow mixture is 0.4 cc/min for acetaldehyde and 0.8 cc/min for ethanol, both out of a total of 100 cc/min. These values correspond to mix accuracies of 0.4% and 0.8%, respectively, and are slightly

smaller than the G.C. response error which is usually less than 2%, as observed in short-term fluctuations in the peak areas for a fixed concentration.

The G.C. response to each concentration of contaminant is recorded in two ways: First, the signal pulse from the G.C. detector is recorded in analog form on a strip chart recorder. Greater concentrations of contaminant produce larger peak heights on the strip chart. Second, the signal pulse is integrated electronically to produce a number proportional to the peak area in millivolt seconds. This number is typed out on a teletype in digital form. Either peak height or peak area may be calibrated and used, but the area of the peak is easier to handle since it is in numerical form.

The G.C. operating parameters to be optimized for each gas include the type of column, the temperature of the column, the column flow velocity, the temperature of the helium ionization detector (HID) and the helium flow through it, and the sampling rate.

For acetaldehyde, the column used was a two-foot section of Chromosorb 102, 1/4 inch in diameter, with a flow rate of 39 cc/min and a temperature of 140°C. The HID was set at 195°C with a discharge flow of 79 cc/min. The sample rate was one sample each 150 seconds. This

period included 35 seconds with the adsorber effluent flowing through the sample loop and 115 seconds with the chromatograph carrier gas flowing through the loop. With these operating conditions, a retention time of 56 seconds was obtained.

For ethanol, we used a two foot section of Chromosorb 101, 1/4 inch in diameter, at 200°C with a flow velocity of 80 cc/min. The HID was set at 200°C with a discharge flow of 110 cc/min. The sample rate was one sample each 100 seconds with the sample flowing through the loop for 25 seconds and the chromatograph carrier gas flowing through the loop for 75 seconds. The retention time was 14 seconds.

The calibration data for acetaldehyde are listed in Table 1a and plotted in Fig. 2. The least squares fit for a fourth order polynomial is given in the table and is also plotted on the figure. The calibration data and the fitted polynomial for ethanol are given in Table 1b and plotted in Fig. 3.

## 2. Development of Data Reduction and Analysis Methods.

The output from the gas chromatograph detector is recorded in two ways as described in section 1 above dealing with the calibration of the chromatograph. The primary source of data used in analysis was the integrated peak area taken from the teletype in punched paper tape form. This tape was fed into the PDP-11 computer <sup>(i)</sup> in the first of two stages of data reduction (in preparation for theoretical analysis).

The PDP-11 first extracts the peak area and time data that correspond to the gas being studied. It ignores the air peak, pressure pulse, and any noise peaks which may be present in the raw data. Next it adjusts the time data for proper zero or starting value and normalizes the area. The normalized area is the ratio of the area for a particular data point divided by the area for the full flow of gas with no adsorption. Finally the PDP-11 punches out a new tape with the corrected time and normalized area and makes a teletype plot of the same values.

Less than one percent of the peak areas appear anomalous. These anomalous readings are attributed to line noise,

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(i) Digital Equipment Corporation PDP 11/05 Time-Sharing computer with 24K (16 bit) words of memory and 4 teletype terminals for simultaneous use.

chromatographic drift, and other spurious factors. Under these conditions, an editing subroutine permits using the peak height output from the strip chart recorder. The peak height reading is measured manually and converted to an equivalent area reading by using a linear interpolation between the adjacent peak areas. This equivalent area is fed manually into the PDP-11 and the process continues as before.

The tape output from the PDP-11 is fed into an IBM-1130 computer for the second and final data reduction step. The IBM-1130 computer punches the normalized area results onto cards for use by the data analysis program on the larger Burroughs-5500 computer. The PDP-11 tape may be used also in making graphs of transmission versus time on a Hewlett-Packard 9100A programmable calculator and plotter. (A new plotter is being added to the PDP-11 system).

The punched cards from the IBM-1130 are combined with other manually punched cards which contain the experimental run parameters such as flow, temperature, bed size, calibration constants, etc., and are put into a Burroughs-5500 computer for analysis and determination of the theoretical parameters. This program converts the normalized area readings to transmission values by

chromatographic drift, and other spurious factors. Under these conditions, an editing subroutine permits using the peak height output from the strip chart recorder. The peak height reading is measured manually and converted to an equivalent area reading by using a linear interpolation between the adjacent peak areas. This equivalent area is fed manually into the PDP-11 and the process continues as before.

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The punched cards from the IBM-1130 are combined with other manually punched cards which contain the experimental run parameters such as flow, temperature, bed size, calibration constants, etc., and are put into a Burroughs-5500 computer for analysis and determination of the theoretical parameters. This program converts the normalized area readings to transmission values by

applying the calibration equation (obtained as described above in section 1) for the particular gas and uses a least-squares fitting routine to determine the best values of the parameters.

Madey and Charles<sup>1</sup> have given the solution to the following one-dimensional dispersion-model transport equation

$$D \frac{\partial^2 C}{\partial x^2} - B \frac{\partial C}{\partial t} - u \frac{\partial C}{\partial x} = 0 \quad (2)$$

$$\text{with } B \equiv \rho k + f \quad (3)$$

where  $D$  ( $\text{cm}^2/\text{sec}$ ) = the longitudinal dispersion coefficient

$C$  (ppm) = concentration or mole fraction of adsorbate

$u$  ( $\text{cm}/\text{sec}$ ) = superficial flow velocity at bed temperature and pressure

$B$  = effective adsorptivity

$\rho$  ( $\text{g}/\text{cm}^3$ ) = adsorbent bulk density

$f$  = adsorbent void fraction

$k$  ( $\text{cc}/\text{gm}$ )  $\equiv \left( \frac{\partial K}{\partial C} \right)_P \cdot \frac{K}{C}$  = slope of the linear adsorption isotherm

$K$  = volume adsorption capacity

$P$  = the total pressure of contaminant plus carrier gas

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1 R. Madey and J. Charles, The Transmission of Carbon Dioxide through Molecular Sieve Adsorbers, in "Developments in Physical Adsorption", edited by L.M. Conjar and D. Camps, Chemical Engineering Progress Symposium Series No. 96, 65, 11-25 (1969), American Institute of Chemical Engineers, New York, New York.

The solution for the transmission  $T$  ( $\equiv C/C_0$ ) at length  $\ell$  is  

$$2T = \exp(u\ell/D) \operatorname{erfc} s_+ + \operatorname{erfc} s_- \quad (4)$$

with

$$2s_{\pm} = \left(\frac{u\ell}{D}\right)^{1/2} \left[ \left(\frac{B\ell}{ut}\right)^{1/2} \pm \left(\frac{ut}{B\ell}\right)^{1/2} \right] \quad (5)$$

We may further define the propagation time  $t_p$ ,  
 and the dimensionless dispersivity  $\Delta$ :

$$t_p \equiv B\ell/u \quad (6)$$

$$\Delta \equiv D/u\ell \quad (7)$$

Eqs. (4) and (5) can be used to describe the transmission versus time curve when the adsorption isotherm is non-linear in the approximation that the dispersion number of the system is small compared with unity. Now the solution can be rewritten in terms of these two parameters as

$$2T = \exp(\Delta^{-1}) \operatorname{erfc} s_+ + \operatorname{erfc} s_- \quad (8)$$

$$\text{with } 2s_{\pm} = (\Delta^{-1/2}) (t_p/t)^{1/2} \pm (t/t_p)^{1/2} \quad (9)$$

The Burroughs 5500 program does a least-squares fit to the parameters  $t_p$  and  $\Delta$ , and then calculates the value of  $B$  and  $D$  from  $t_p$ ,  $\Delta$ ,  $\ell$ , and  $u$ .



3. The Generation and Analysis of Experimental Data for the Transport of 100 ppm Acetaldehyde through a Cylindrical Bed Packed with Activated Carbon Granules.

The transport of 100 ppm acetaldehyde ( $\text{CH}_3\text{CHO}$ ) in helium through an adsorber bed, 10.0 cm long and 0.466 cm inside diameter packed with 0.688 grams of desorbed "Columbia" type 4 LXC 12/28 activated carbon (ii), has been studied for volumetric flows of 1000, 500, 200, 100, 50, 20 and 10 standard cubic centimeters (scc) per minute at a bed temperature of  $298^\circ\text{K}$  ( $25.0^\circ\text{C}$ ). Dividing the volumetric flow at bed temperature and pressure by the bed area results in a range of superficial flow velocities from 1.1 to 104 cm/sec. The running time for an experiment then varied from 40 minutes to 41 hours. To insure reproducibility of experimental results in the longer runs, it was necessary to check the flow of gas through the adsorber bed periodically during the run and make adjustments to the flow controller as needed.

The parameters of best fit for the acetaldehyde runs with the higher flow velocities (of 100 scc/min) and above) are listed in Table 2. Complete consistency of results within experimental error are seen for all repeat runs.

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(ii) Union Carbide 12/28 mesh activated carbon.

The parameter B is constant within experimental error. The adsorption capacity K is constant also within experimental error; however, K shows a systematic decrease with decreasing flow, which comes about because the pressure drop across the adsorber bed decreases as the flow decreases. The pressure drop across the bed varied from 9.3 cm Hg at 1000 scc/min to 0.9 cm Hg at 100 scc/min.

The parameters  $\Delta$  and D are also consistent for repeated runs within errors for all the high flow runs in Table 2; however, these parameters are functions of the superficial flow velocity.

Table 3 lists the parameters for the acetaldehyde runs at the lower flow velocities of 50 scc/min and below. Good agreement between the values of both B and K are seen for repeat experiments. They are also constant within error over this range of flow velocities, and K does not exhibit the decreasing effect noticed in the high-flow series because the pressure drop across the bed at all low flow velocities is small.

Excellent agreement between the values of D and  $\Delta$  are also seen for repeat runs at 50 scc/min but not at 20 scc/min. The 20 scc/min runs were 20 hours long and the results were subject to the accumulative effects of

drift in the G.C., flow, and barometric pressure; it is clear, however, that D does not vary much with flow at the lower flow velocities. The average values at 50, 20, and 10 scc/min are 0.04, 0.07, and 0.08 cm<sup>2</sup>/sec, and are constant within the variation noted in the repeat runs at 20 scc/min.

Figure 4 is a plot of one experimental data set with theoretical curves at each of the flow velocities studied.

4. The Generation and Analysis of Experimental Data for the Transport of 100 ppm Ethanol through a Cylindrical Bed Packed with Activated Carbon Granules.

The transport of 100 ppm ethanol ( $C_2H_5OH$ ) in helium through an adsorber bed, 10.0 cm long and 0.453 cm inside diameter packed with 0.590 grams "Columbia" 4LXC 12/28 activated carbon, has been studied for volumetric flows of 1000, 500, 200 and 100 scc/min at a bed temperature of 298°K (25.0°C). The corresponding range of superficial flow velocities ranged from 110.7 to 11.5 cm/sec at bed temperature and pressure with experiment running times from about 2 hours to 12 hours. The times for ethanol were about 3 times as long as acetaldehyde for similar flow velocities because ethanol has a greater adsorptivity.

The parameters of best fit for the ethanol runs are listed in Table 4. All parameters are consistent within experimental error for repeated runs.

For ethanol, B and K are nearly constant as the flow varies. The slight decrease in B and K with decreasing flow is due to the bed pressure drop effect in a manner similar to that observed with acetaldehyde.

The parameters D and  $\Delta$  vary over about two orders of magnitude as the flow changes by one order of magnitude.

Figure 5 is a plot of one experimental data set with theoretical curves at each of the flow velocities studied for ethanol.

5. A Comparison of the Volume Adsorption Capacity of Activated Carbon for 100 ppm Acetaldehyde, Ethanol, and Acetone.

We compare the volume adsorption capacity (reduced to STP) of activated carbon at 25°C for acetaldehyde, ethanol, and acetone (iii) at 100 ppm concentrations in helium at a total pressure P of one atmosphere. The volume adsorption capacity K is calculated from the slope of the adsorption isotherm:

$$K \approx C_o \left( \frac{\partial K}{\partial C} \right)_P \quad (10)$$

Here  $C_o$  is the inlet concentration of the contaminant gas. Eq. (10) is exact for a linear isotherm and approximate for a non-linear isotherm.

The values of K are determined from runs at the lower flow rates where the pressure drop across the bed is small and the total pressure P is constant. The results are given in Table 5. Acetone has the largest adsorption capacity and acetaldehyde the least.

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(iii) Acetone results are described in the Semi-Annual Status Report No. 2 (March 15, 1975), KSUPP-TR-74-1

## ACTIVITIES IN PROGRESS AND PLANNED

Activities in progress include the following:

1. The Generation and Analysis of Experimental Data on the Transport of Freon-113 through Activated Carbon.

The study of freon-113 will include the calibration of the chromatograph for freon-113, the selection of optimum column conditions, the analysis of the time-dependent transmission data, and the determination of the volume adsorption capacity of freon-113.

2. The Generation and Analysis of Additional Experimental Data on the Transport of Ethanol through Activated Carbon.

Additional data for ethanol are being generated in the region of lower flow velocities to determine the behavior of the dispersion parameters at superficial flow velocities less than 50 cm/sec.

3. The Interpretation of Dispersion as a Function of Superficial Flow Velocity for Acetaldehyde and Ethanol.

The results of the experiments with acetaldehyde and ethanol are being correlated with known mathematical models of dispersion as a function of flow velocity.

Planned activities include the following:

1. Preparation of Papers for Publication.

We have generated a great deal of data which is currently in various stages of analysis. During the forthcoming year, we plan to continue work in progress leading to publications on the following topics:

- (1) The Adsorption Isotherm of Acetone on Activated Carbon at 25°C.
  - (2) The Volume Adsorption Capacity of Activated Carbon at 25°C for 100 ppm Concentrations of Acetaldehyde, Ethanol, Acetone, and Freon-113.
  - (3) The Dispersion Model Interpretation of the Flow Velocity Dependence of the Transport of Acetaldehyde and Ethanol through Activated Carbon.
2. The Generation of Experimental Data on the Adsorption Isotherms of Acetaldehyde, Ethanol, and Freon-113 on Activated Carbon at 25°C.

Experiments are planned that will determine the volume adsorption capacity of carbon for concentrations of acetaldehyde, ethanol, and freon-113 which are less than 100 ppm. The adsorption capacity will be fitted as a function of concentration to produce the isotherms.

3. The Generation of Experimental Data on the Transport of Methane through Activated Carbon.

The study of methane will include the calibration of the chromatograph for methane, the selection of optimum detector operating configuration, the analysis of the time-dependent transmission data, and the interpretation of the results.

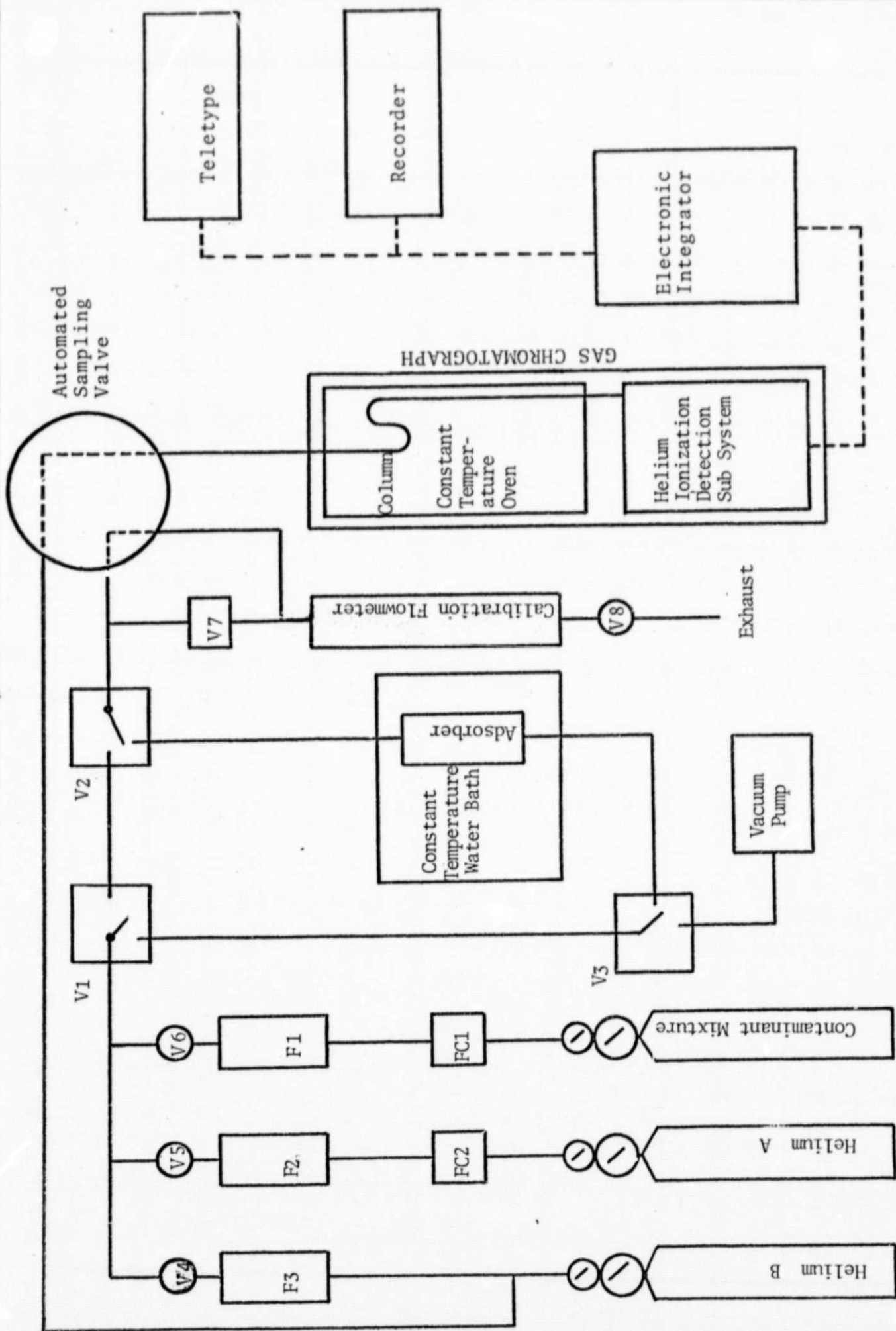


Fig. 1. Adsorption Apparatus



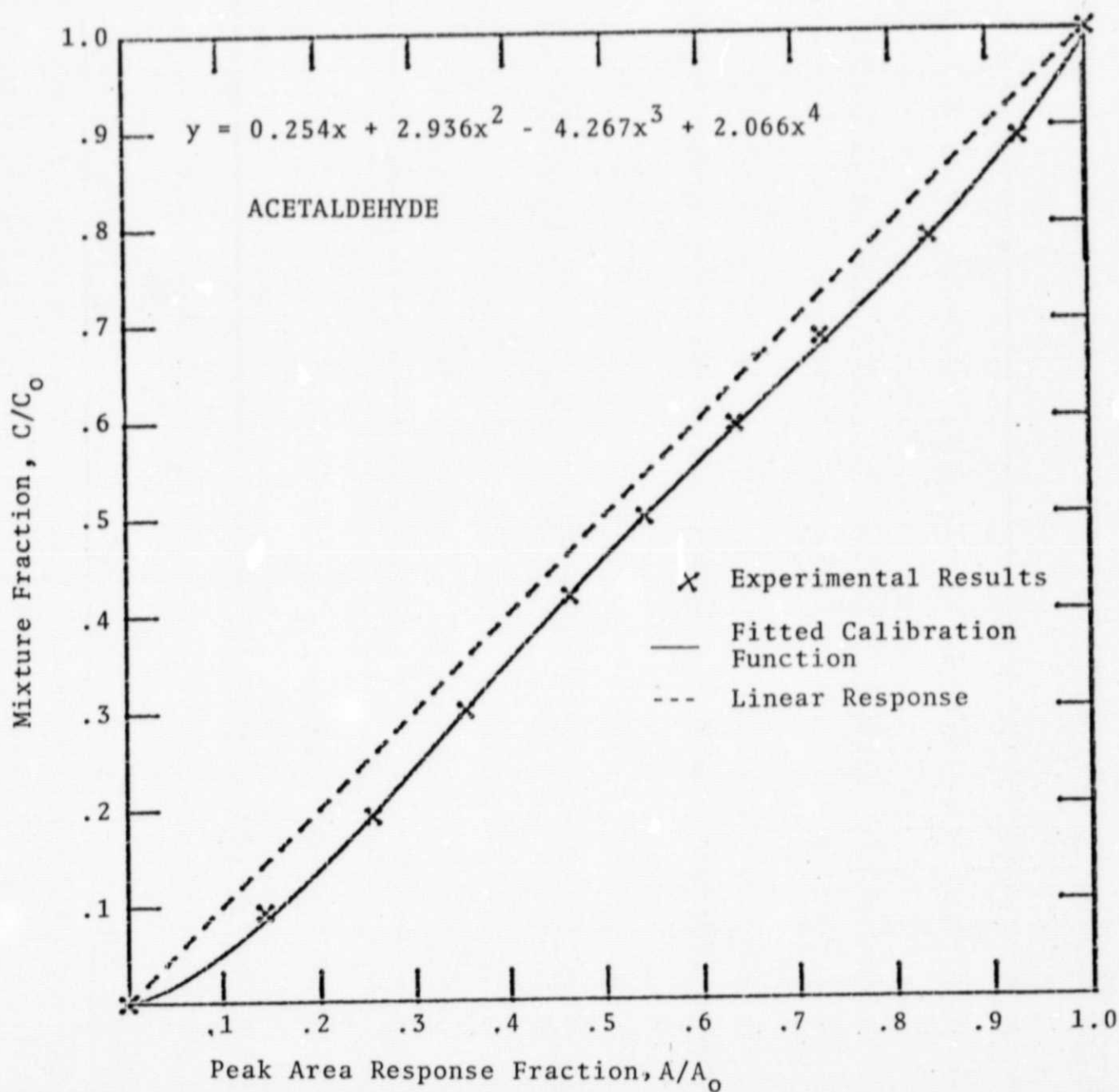


Fig 2. Calibration plot of mixture fraction vs. peak area response fraction of the gas chromatograph for 100 ppm acetaldehyde.

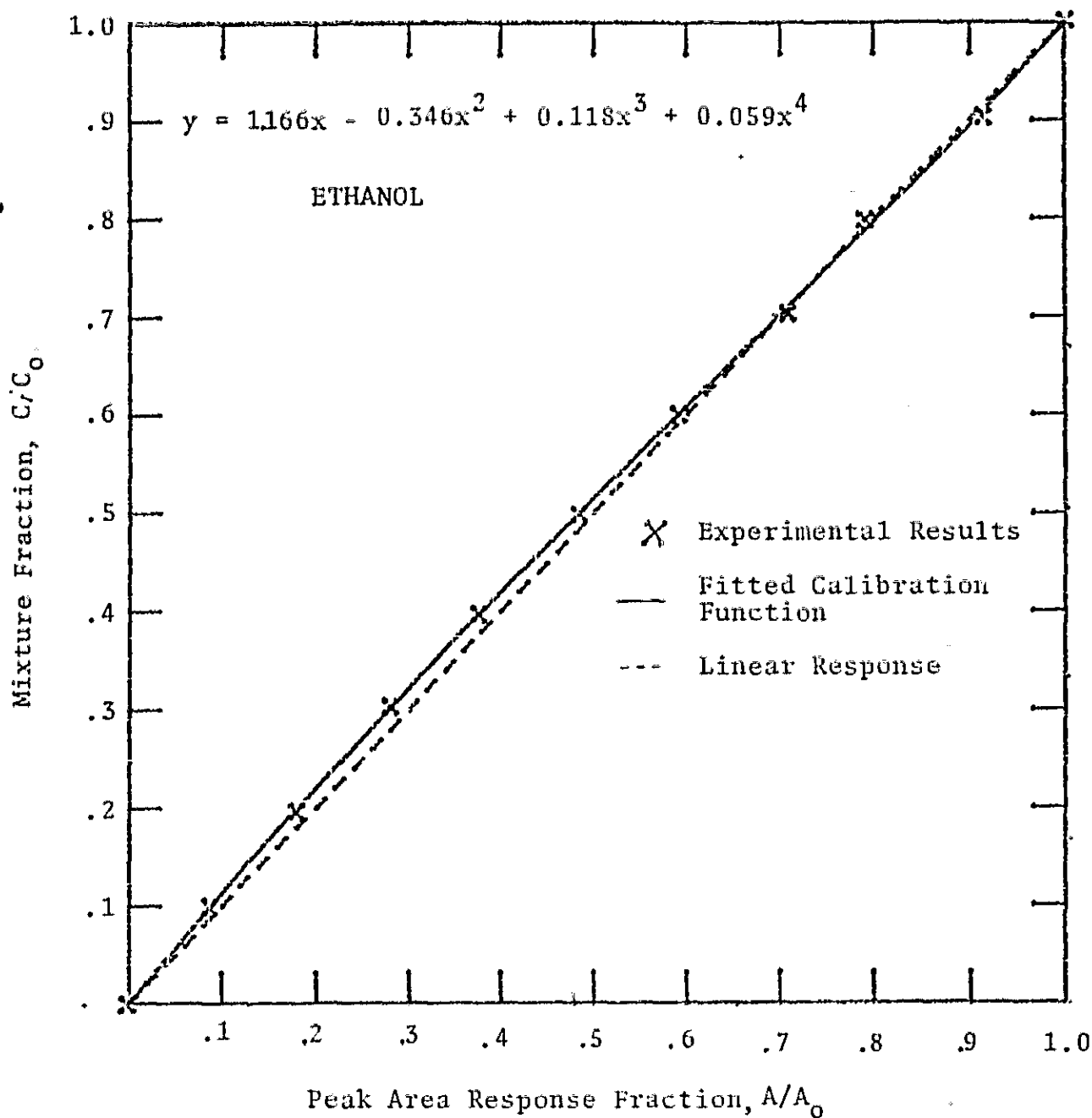


Fig 3. Calibration plot of mixture fraction vs peak area response fraction of the gas chromatograph for 100 ppm ethanol.

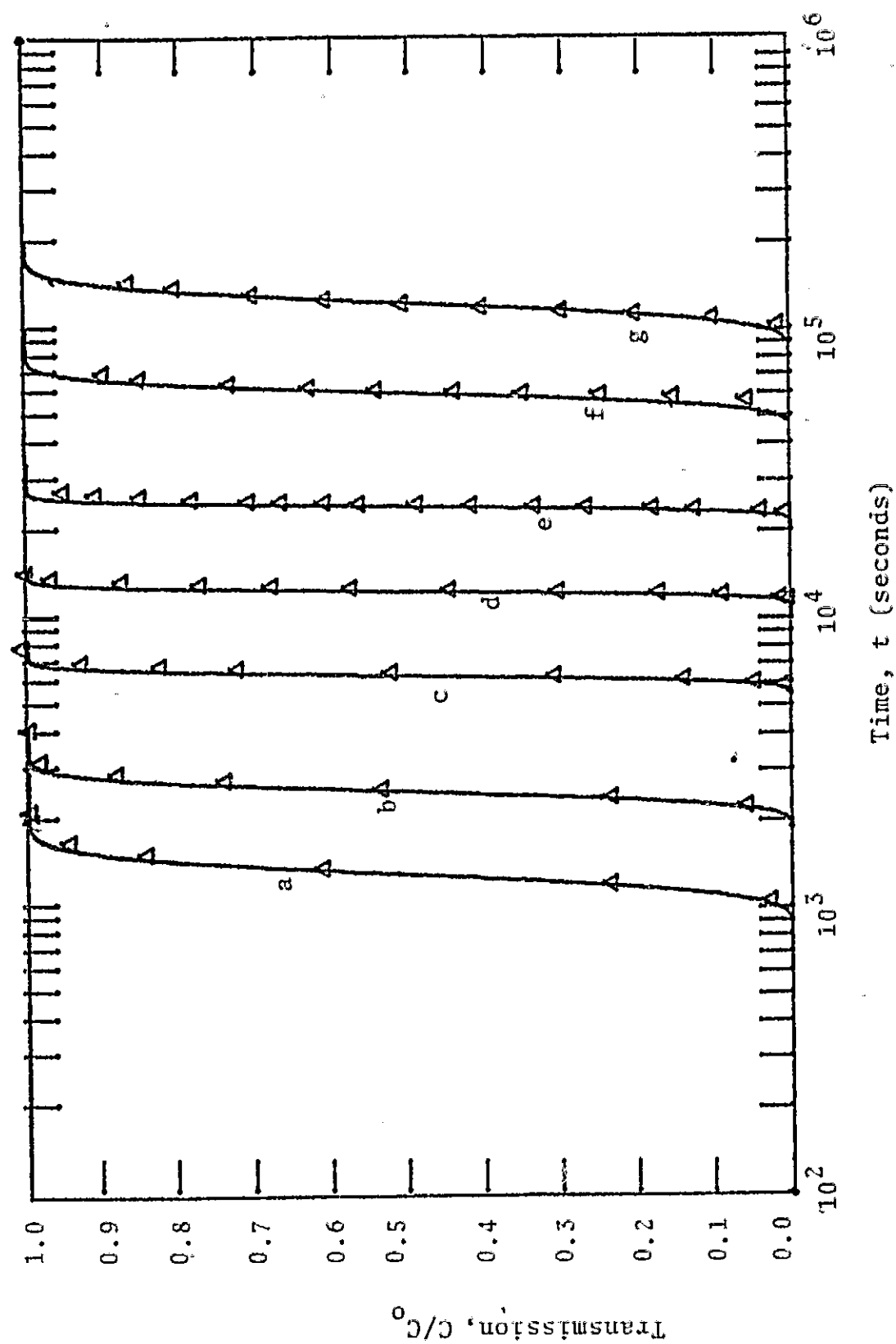


Fig 4: Transmission of 100 ppm Acetaldehyde in Helium flowing through an adsorber bed at 25.0°C, 10 cm long and 0.466 cm inside diameter packed with 0.688 grams of "Columbia" 4LXC 12/28 activated carbon, with volumetric flows of (a) 1000 (b) 1000 (c) 500 (d) 200 (e) 100 (f) 20 (g) 10 scc/minute.

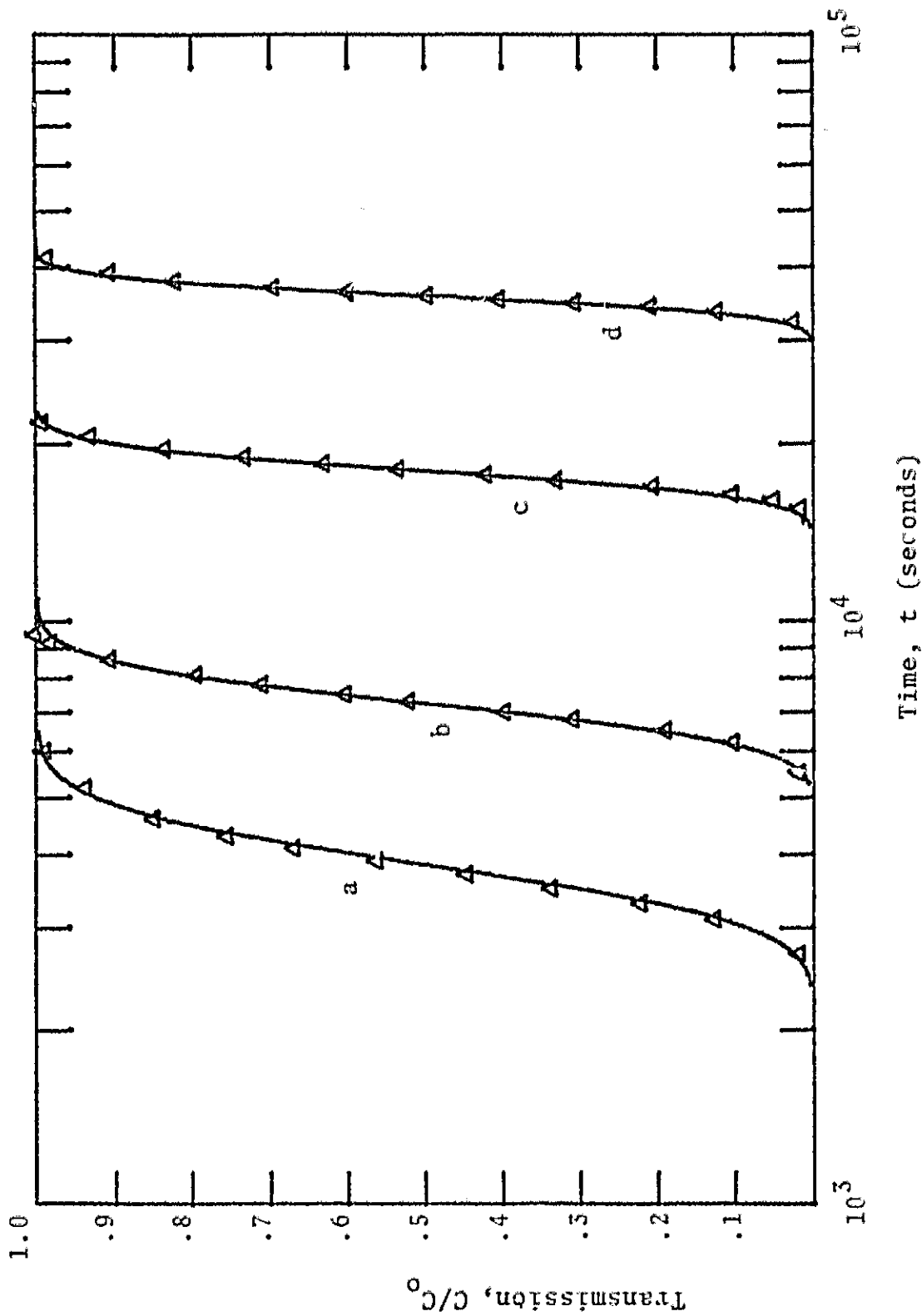


Fig. 5: Transmission of 100 ppm Ethanol in Helium at 25.0°C flowing through an adsorber bed, 100 cm long and 0.453 cm inside diameter packed with 0.590 grams of "Columbia" 4LXC 12/28 activated carbon, with volumetric flows of (a) 1000 (b) 500 (c) 200 (d) 100 sec/minute.

Table 1

Calibration mixture fraction and relative gas chromatograph response for 100 ppm acetaldehyde and 100 ppm ethanol.

## a. Acetaldehyde

Response Area Fraction, x	Mixture Fraction, y
1.000	1.000
0.932	0.889
0.839	0.786
0.727	0.683
0.636	0.595
0.541	0.499
0.463	0.418
0.354	0.301
0.255	0.193
0.143	0.094

## b. Ethanol

Response Area Fraction, x	Mixture Fraction, y
1.000	1.000
0.914	0.903
0.790	0.798
0.707	0.702
0.591	0.600
0.483	0.499
0.376	0.397
0.278	0.303
0.179	0.196
0.086	0.099

$$y = C_1x + C_2x^2 + C_3x^3 + C_4x^4$$

$$C_1 = 0.2541$$

$$C_2 = 2.9361$$

$$C_3 = -4.2667$$

$$C_4 = 2.0655$$

$$y = C_1x + C_2x^2 + C_3x^3 + C_4x^4$$

$$C_1 = 1.1664$$

$$C_2 = -0.3460$$

$$C_3 = 0.1181$$

$$C_4 = 0.0594$$

Table 2. Least squares values of the theoretical parameters for 100 ppm acetaldehyde in helium at 25.0°C flowing through an adsorber bed 10 cm long and 0.466 cm inside diameter packed with 0.688 grams of "Columbia" 4 LXC 12/28 activated carbon with volumetric flows from 100 to 1000 scc/min.

Kun #	Nominal Volumetric Flow (scc/min)*	Superficial Flow Velocity $u \pm \delta u$ (cm/sec)	Effective Adsorptivity $10^{-2}(B \pm \delta B)$	Volume Adsorption Capacity $(K \pm \delta K)$ (scc/gm)*	Dispersion Coefficient $10^2(D \pm \delta D)$ (cm <sup>2</sup> /sec)	Dimensionless Dispersion $10^4(\Delta \pm \delta \Delta)$
6	1000	103.5±4.7	136.8±6.2	3.20±0.31	860±74	82.8±6
6R1	1000	104.6±4.8	137.9±6.4	3.19±0.30	980±83	23.4±7
6R2	1000	104.0±5.6	137.5±7.4	3.18±0.33	878±80	84.2±6
4	500	53.8±2.2	137.4±5.7	3.10±0.28	228±17	42.2±3
4R1	500	53.8±2.3	137.3±5.9	3.10±0.29	216±17	40.0±3
2	200	21.78±.98	139.7±6.2	3.11±0.30	26.9±1.9	12.3±0.7
2R1	200	21.83±1.01	139.0±6.5	3.11±0.30	27.7±2.0	12.6±0.7
2R2	200	21.48±1.06	138.2±6.8	3.09±0.31	23.7±2.0	10.5±0.6
5	100	10.78±.50	135.8±6.2	3.04±0.29	7.17±0.46	6.63±0.4
5R1	100	10.77±.49	134.9±6.2	3.02±0.29	7.60±0.48	7.03±0.3

\* Quantities at S.T.P.; others are at bed temperature and pressure

Table 4. Least squares values of the theoretical parameters for 100 ppm ethanol in helium at 25.0°C flowing through an adsorber bed 10 cm long and 0.453 cm inside diameter packed with 0.590 grams of "Columbia" 4LXC 12/28 activated carbon.

Run #	Nominal Volumetric Flow (scc/min)*	Superficial Flow Velocity $u \pm \delta u$ (cm/sec)	Effective Adsorptivity $10^{-2}(B \pm \delta B)$	Volume Adsorption Capacity $(K \pm \delta K)$ (scc/gm)*	Dispersion Coefficient $10^{-2}(D \pm \delta D)$ (cm <sup>2</sup> /sec)	Dimensionless Dispersion $10^4(\Delta \pm \delta \Delta)$
2	1000	110.7 $\pm$ 3.6	428 $\pm$ 14	10.95 $\pm$ 0.60	1879 $\pm$ 82	170 $\pm$ 5
2R1	1000	110.6 $\pm$ 3.3	434 $\pm$ 13	11.03 $\pm$ 0.57	1847 $\pm$ 76	167 $\pm$ 5
1	500	57.2 $\pm$ 1.8	446 $\pm$ 14	11.05 $\pm$ 0.58	481 $\pm$ 20	84.2 $\pm$ 2
1R2	500	57.2 $\pm$ 1.7	419 $\pm$ 12	10.33 $\pm$ 0.53	497 $\pm$ 19	87.0 $\pm$ 2
1R3	500	57.0 $\pm$ 1.7	417 $\pm$ 12	10.37 $\pm$ 0.53	468 $\pm$ 18	82.1 $\pm$ 2
3	200	22.9 $\pm$ .7	418 $\pm$ 13	10.31 $\pm$ 0.54	79.6 $\pm$ 2.8	34.4 $\pm$ 0.7
3R1	200	23.0 $\pm$ .7	417 $\pm$ 13	10.25 $\pm$ 0.54	79.1 $\pm$ 2.9	34.4 $\pm$ 0.7
4	100	11.5 $\pm$ .3	412 $\pm$ 12	10.21 $\pm$ 0.54	20.9 $\pm$ 0.7	18.3 $\pm$ 0.3

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\* Quantities at S.T.P., others are at bed temperature and pressure

Table 3. Least squares values of the theoretical parameters for 100 ppm acetaldehyde in helium at 25.0°C flowing through an adsorber bed 10 cm long and 0.466 cm inside diameter packed with 0.688 grams of "Columbia" 4 LXC 12/28 activated carbon with volumetric flows from 10 to 50 scc/min.

Run #	Nominal Volumetric Flow (scc/min)*	Superficial Flow Velocity $u \pm \delta u$ (cm/sec)	Effective Adsorptivity $10^{-2}(B \pm \delta B)$	Volume Adsorption Capacity $(K \pm \delta K)$ (scc/gm)*	Dispersion Coefficient $10^2(D \pm \delta D)$ (cm <sup>2</sup> /sec)	Dimensionless Dispersion $10^4(\Delta \pm \delta \Delta)$
3R5	50	5.45±.28	133.8±6.8	2.97±0.30	4.22±0.26	7.72±0.26
3R6	50	5.44±.26	133.2±6.3	2.96±0.29	4.19±0.24	7.68±0.25
7	20	2.20±.10	132.8±6.2	2.95±0.28	8.95±0.48	40.5 ±1.2
7R1	20	2.18±.12	133.2±7.6	2.98±0.31	4.69±0.28	21.4 ±0.3
8	10	1.10±.05	135.2±6.3	2.99±0.29	7.78±0.38	70.6 ±0.8

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\* Quantities at S.T.P.; others are at bed temperature and pressure



Table 5

The volume adsorption capacity of "Columbia" 4LXC 12/28 activated carbon at 25.0°C for 100 ppm concentrations of acetaldehyde, ethanol, and acetone in helium at a total pressure of one atmosphere.

Contaminant gas	Concentration (ppm)	Volume Adsorption Capacity ( $K \pm \delta K$ ) (scc/g)
Acetaldehyde	100	$3.0 \pm 0.3$
Ethanol	100	$10.3 \pm 0.5$
Acetone	105	$20.2 \pm 0.4$